50 iterations, 64 colors (clusters)

Sequiential compresson

Image Size	Time
640 : 480	6.278798 s
800 : 600	9.805754 s
1600 : 900	29.638070 s
1920 : 1080	43.966289 s
3840 : 2160	177.867248 s

- In my algorithm I use structures for: the image, the clusters (they hold **RGB** values like: [[RGB], [RGB], [RGB], ...]) and pointer to the cluster an image point belongs to.
- I use two main (three if I count the iterations) for loops:
    - go through every point of the picture and for every cluster find the smallest distance (Euclidean distance) of the **RGB** values to the point, when found assign the cluster with the smallest distance to the point (using the above aforementioned structure).
    - go through every cluster, average up the points that belong to that cluster and assign the average to the cluster.

OpenMP

- The parallelization with **openMP** was very successful at my end. I used two **#pragma omp parallel for** before my main loops.
- This worked really well because I don't use a strucutre for my **sum** and **n** of the clusters (which I later had to use to implement it on **openCL**). On the second for loop (which I go through every cluster), I go through each point and find the point of the cluster and calculate its **sum** and **n** "on the fly". For this, my **openMP** parallelization was very successful. But, because of this I had to pay time for the sequential compression, which is very slow.
- **openMP** parallelization has the same speedup of the sequential for every picture size.

*The speedups are sequiential algorithm compresson time divided by current parallelization algorithm time.

Threads	Image Size	Time	Speedup
16	640 : 480	0.531060 s	11.82314239445637

Threads	Image Size	Time	Speedup
16	800 : 600	0.839067 s	11.68649702586325
16	1600 : 900	2.548885 s	11.627856886442503
16	1920 : 1080	3.760438 s	11.691799997766218
16	3840 : 2160	14.870997 s	11.960680780179029
32	640 : 480	0.565514 s	11.102816199068458
32	800 : 600	0.960154 s	10.21268879783868
32	1600 : 900	2.422474 s	12.234628730793396
32	1920 : 1080	3.553231 s	12.373608414426196
32	3840 : 2160	13.981206 s	12.721881645975317
64	640 : 480	0.524497 s	11.971084677319412
64	800 : 600	0.675236 s	18.695538773339027
64	1600 : 900	1.572185 s	18.851515565916223
64	1920 : 1080	2.169725 s	20.26353063176209
64	3840 : 2160	9.463065 s	18.795944865643424

Original Spiderman picture	Compressed with openMP parallelization

OpenCL

Host

- I initialize variables:
  - clusters.
  - **sum** for clusters - [[sum for R value, sum for G value, sum for B value], ...].
  - **n** for clusters - how many points does the cluster have, we use this for the .calculation of the average.
  - which point has which cluster.
- set the clusters to random point of the image.
- create memory objects which are readable and writeable.
- set the kernels' arguments.
- divide the workload:
  - first kernel: local item size is 256, global is the size of the image.
  - second kernel: local item size is 64, global is 256.
- execute kernels for every iteration.
- calculate time using openMP function.
- read objects back to the host where we set them to the image.
- free up memory.

Device

We have a one .cl kernel file which has 2 functions.

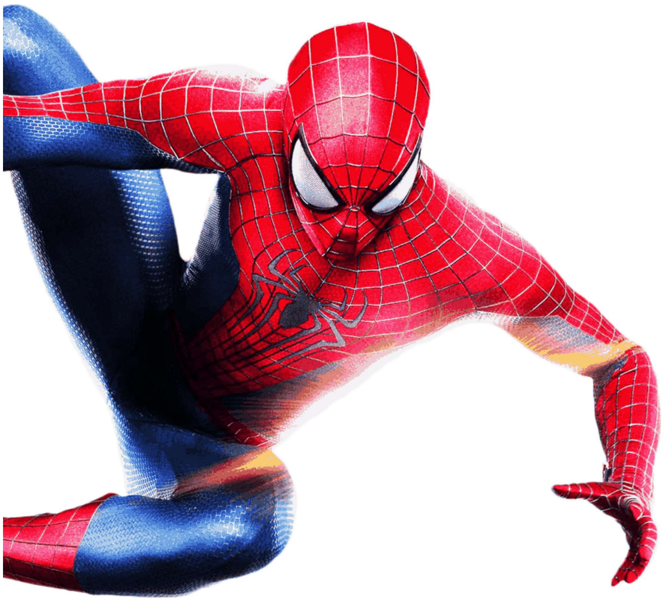
- **Min_euc_dist**
  - assign every point to the nearest cluster (I went through this earlier).
  - have to update the cluster **sums** and **n**.
    - I do this by using the **atomic_add** and **atomic_inc** funciton from openCL.
- **Set_avg**
  - here we go through every cluster and use the above aforementioned structures for **sum** and **n** to set the average for each cluster.
  - main problem I had with parallelization on openCL was the giving a random point to a cluster when it was empty. With a little bit of research, I solved this by passing a ulong seed (123456789) to the kernel and from it calculating a random uint.
  - also, I had to reset the **sums** and **n** for every cluster passing, so that the next one has them set at 0.

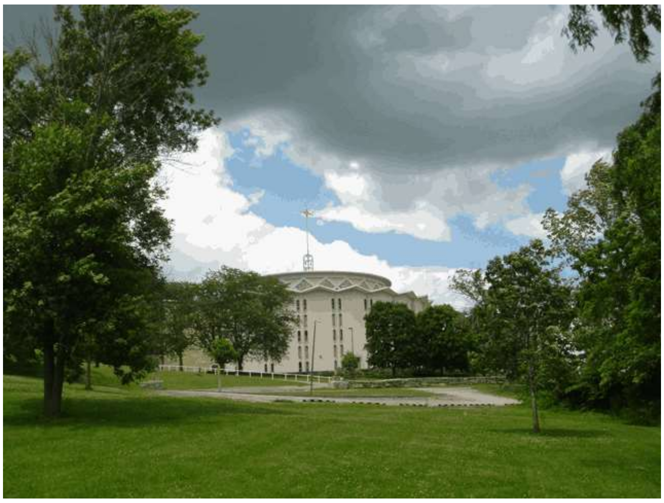
Results

Image Size	Time	Speedup
640 : 480	0.116246 s	54.01302410405519
800 : 600	0.171157 s	57.29099014355241

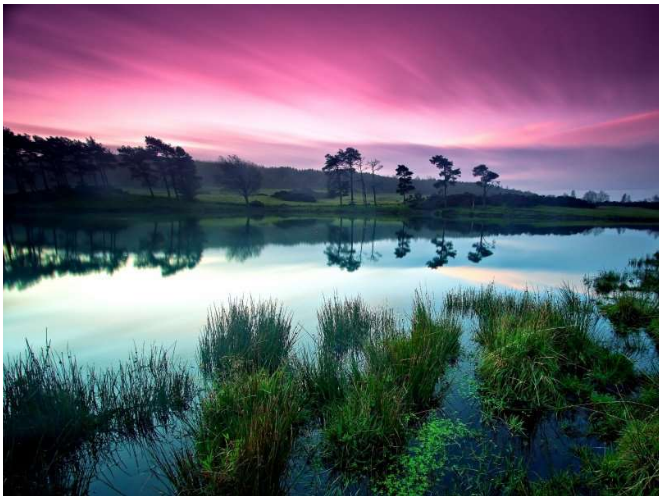
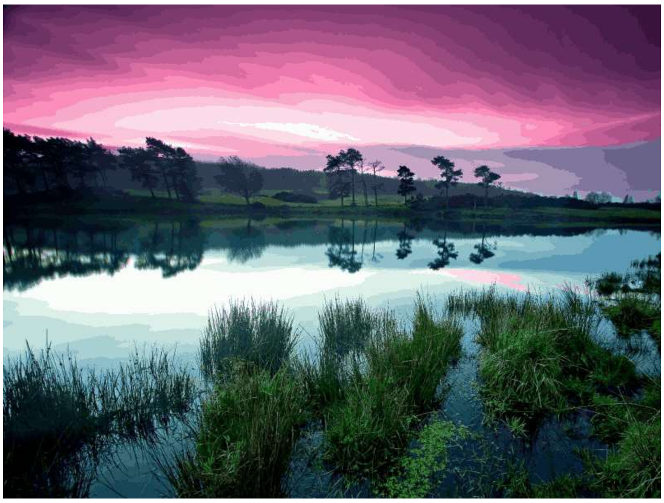
Image Size	Time	Speedup
1600 : 900	0.460573 s	64.35042870511298
1920 : 1080	0.648512 s	67.79564449077273
3840 : 2160	2.518930 s	70.61222344408141

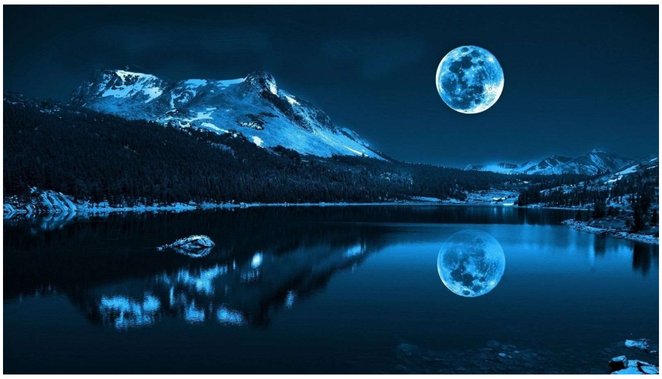
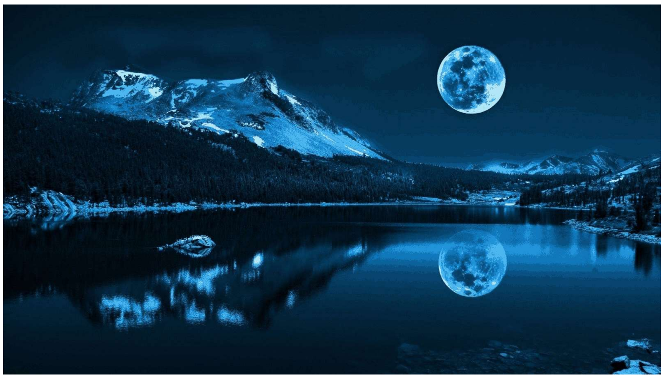
- The spiderman picture is a 940 : 850 and, it takes 0.280680 seconds on GPU.

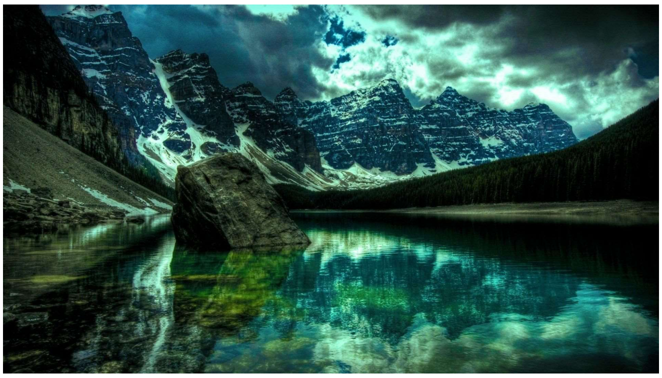
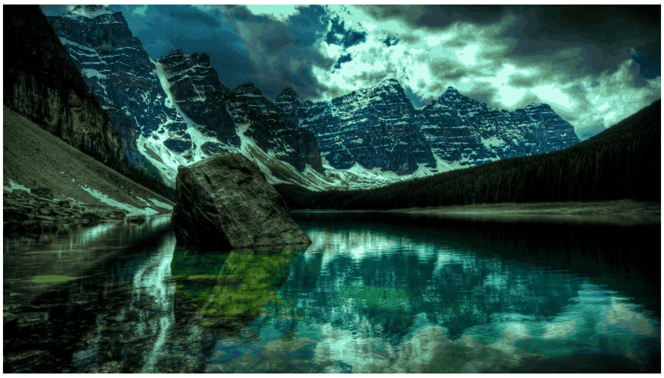
Original Spiderman picture	Compressed with openCL GPU parallelization
	

Original 640 480 picture	Compressed with openCL GPU parallelization
	

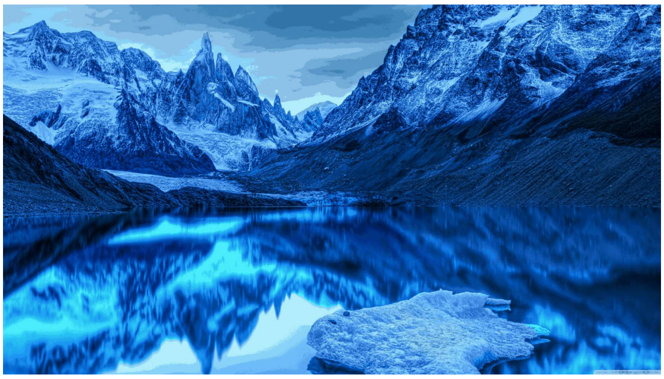
Original 800 600 picture	Compressed with openCL GPU parallelization

Original 800 600 picture	Compressed with openCL GPU parallelization
	

Original 1600 900 picture	Compressed with openCL GPU parallelization
	

Original 1920 1080 picture	Compressed with openCL GPU parallelization
	

Original 3840 2160 picture	Compressed with openCL GPU parallelization

Original 3840 2160 picture	Compressed with openCL GPU parallelization
	

Local memory implementation

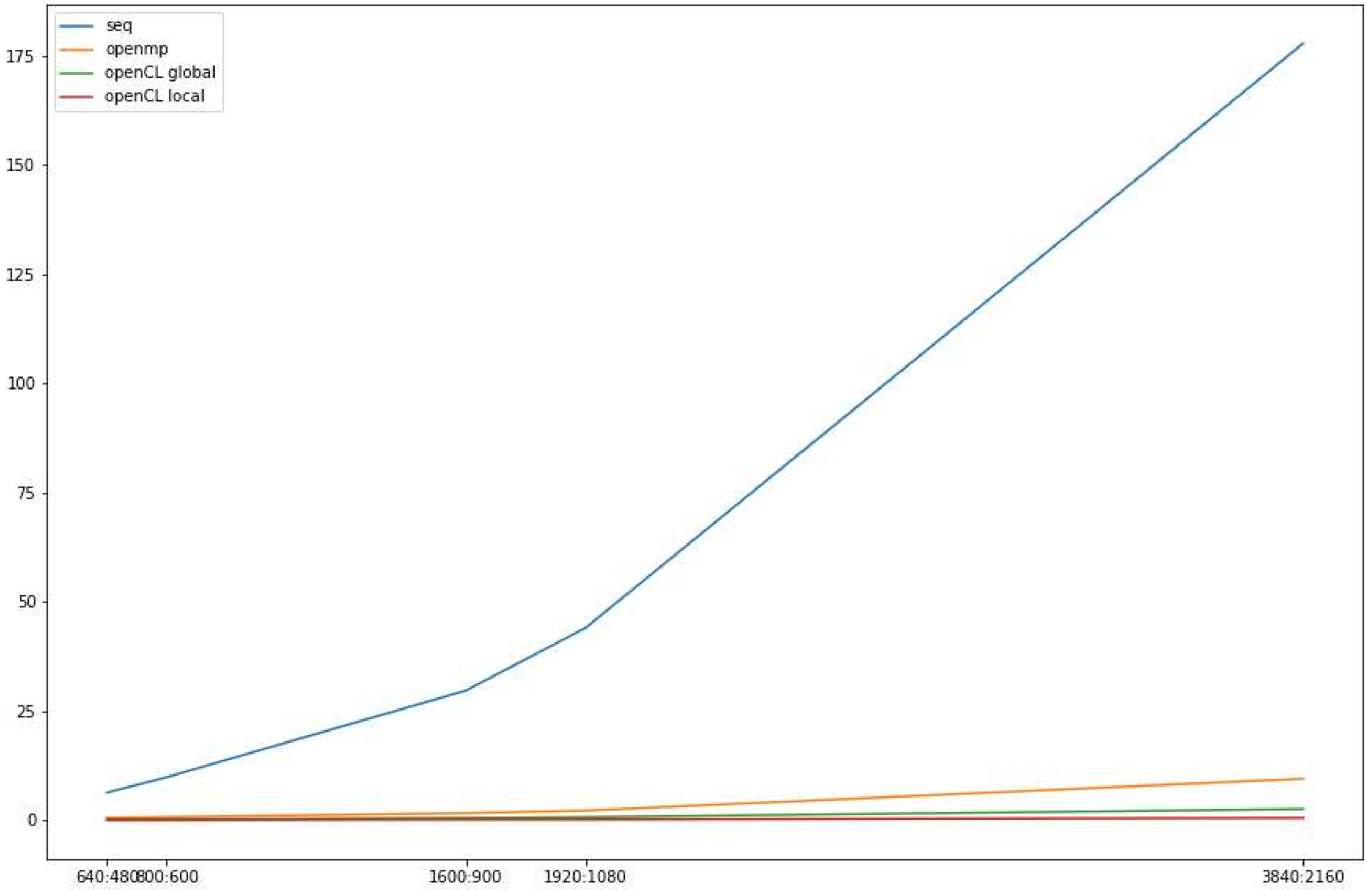
- Just save the clusters in a local variable and put a barrier.

Using openCL with local memory implementation yielded the best current best results. The compressed image quality was the same as the before results.

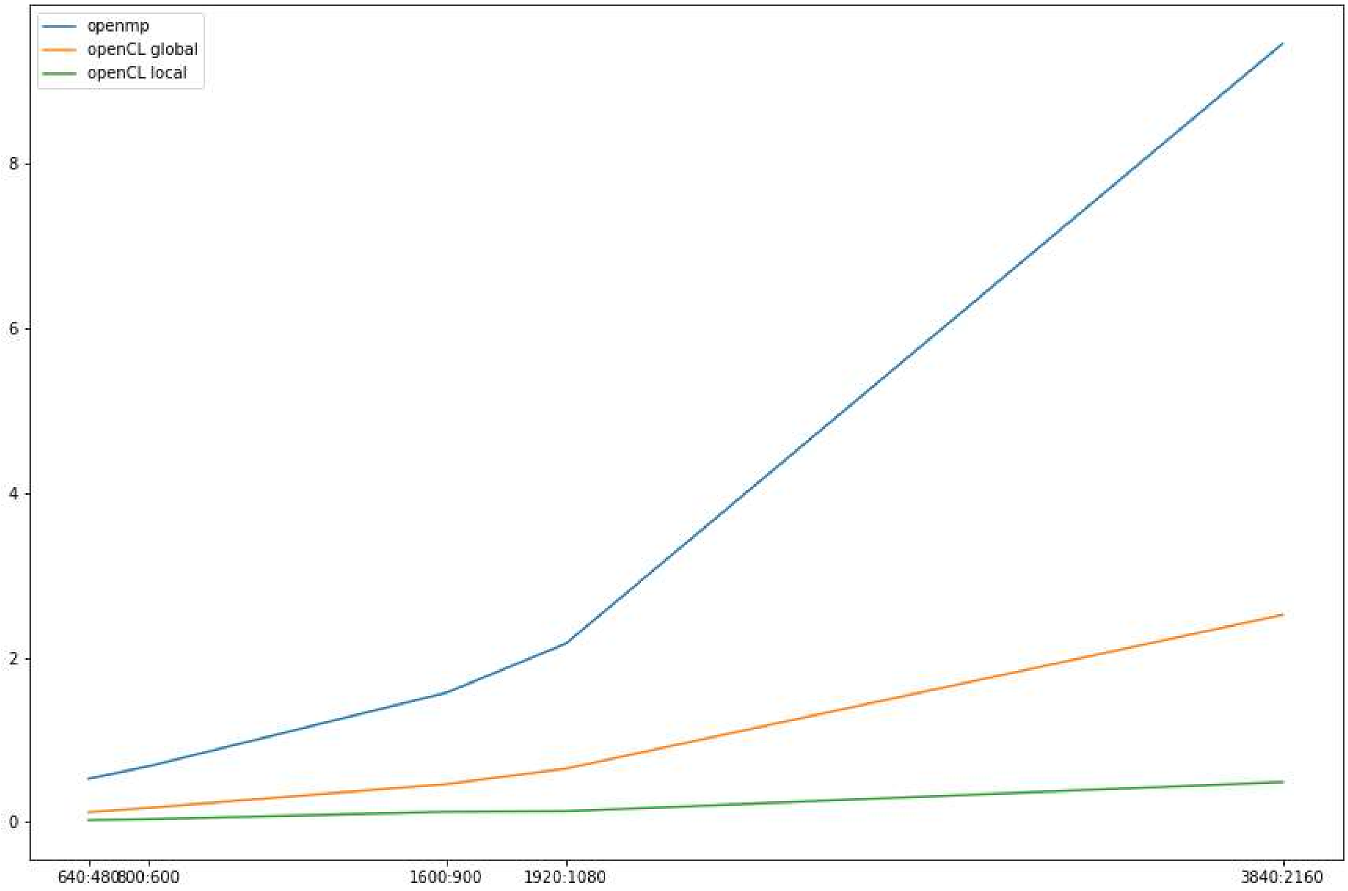
Image Size	Time	Speedup
640 : 480	0.022038 s	284.9077956257374
800 : 600	0.034357 s	285.4077480571645
1600 : 900	0.122467 s	242.0086227310214
1920 : 1080	0.129836 s	338.62941711081675
3840 : 2160	0.485366 s	366.4600487055129

Graph results

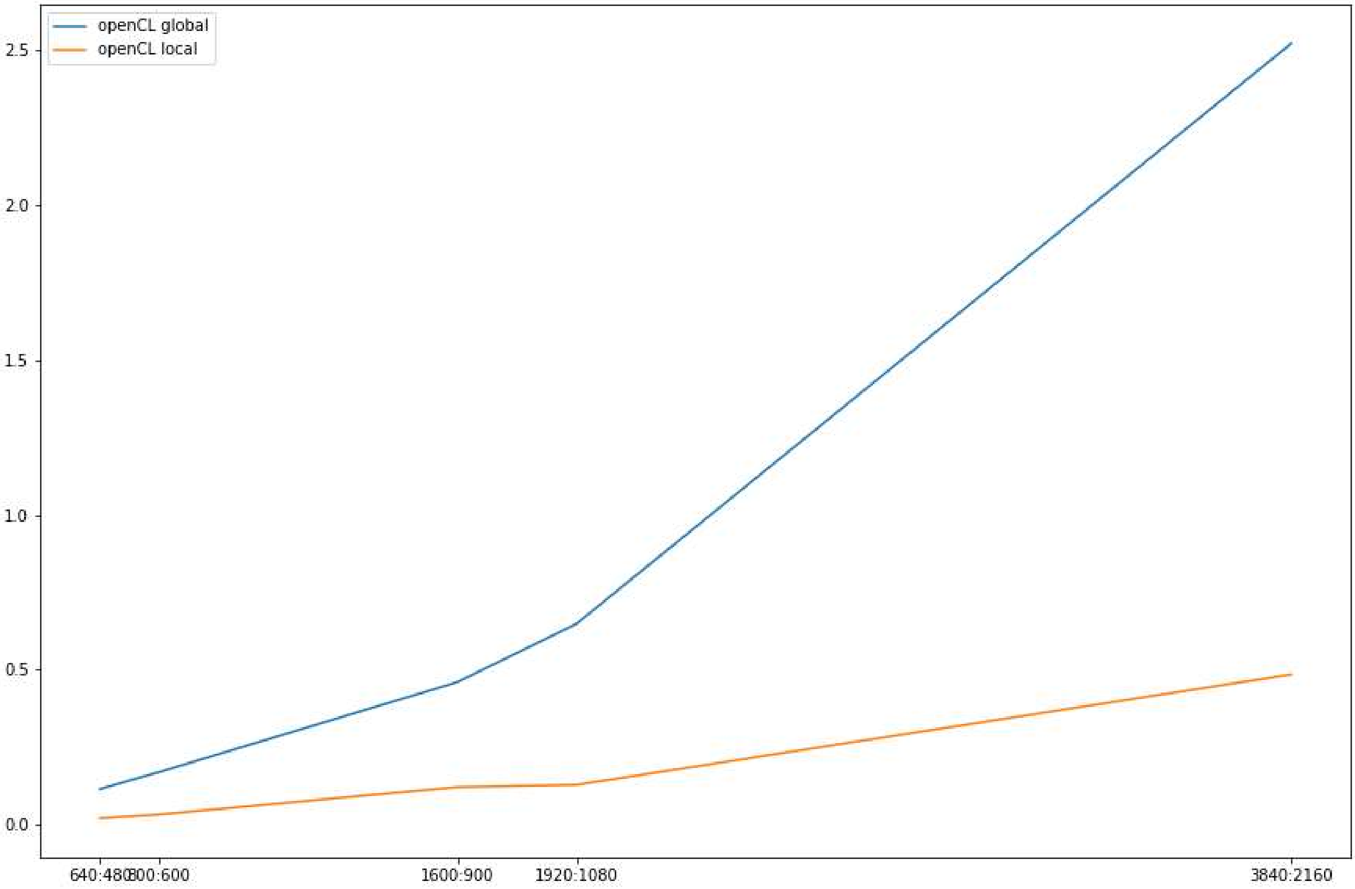
Results for all the algorithms.



Results for all the parallel algorithms.



Results for openCL parallelization with local and global memory.


openCL global
openCL local
640:480
800:600
1600:900
1920:1080
3840:2160